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PROCESS AND DEVICE FOR VERIFICATION OF A FILTER ELEMENT BY INFRARED RADIATION

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PROCESS AND DEVICE FOR VERIFICATION OF A FILTER ELEMENT BY INFRARED RADIATION

[Procede et dispositif de controle d'un element filtrant par rayonnement infrarouge]

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Domain of the invention /1*

The present invention relates to a process and to a device for verification of filter elements and applies particularly to expert reports and verifications in the manufacturing of filters intended for fine filtration, such as metallic cloth, sintered elements, composite elements or elements made of ceramic.

The invention applies more generally to the study and verification of the characteristics of porous materials.

* [Numbers in the right margin indicate pagination of the foreign text.]

Prior art

In industry, filter elements are defined by their filtration power, among other things. This characteristic is currently measured and verified either by the so-called "glass balls" method or by the so-called "bubble point" method.

The so-called "glass balls" method, according to which one proceeds with a count of calibrated glass balls which have passed through the filter mixed with a liquid under pressure, cannot be applied in production and is only used for study purposes because it is destructive.

The so-called "bubble point" method consists of immersing the filter in a liquid such as alcohol or an oil and of applying a gas, whose pressure is gradually increased, through the filter. The appearance of the first bubble characterizes the lowest point of the filter, that is to say the widest mesh size. Such a method is not destructive and can be used in production. However, it has the disadvantage, taking into account the fluids which are used, liquid and gas, of contaminating the filter elements, and it therefore necessitates an operation of cleaning of the elements which can be very difficult and expensive. In particular, in the majority of applications of the space domain, it is essential for the filters not to contain any trace of greases, because they /2
are incompatible with filtered fluids such as oxygen.

There are known methods for study and analysis of materials, furthermore, which use infrared spectrography or which are based on the application, on the material, of a beam of visible light or infrared radiation with predetermined characteristics and on the observation of the light reflected by the material.

Such processes are poorly suited to industrial operation and are not provided specifically for verifying the integrity of filter elements.

Object and brief description of the invention

The present invention aims to remedy the aforementioned disadvantages and to make it possible to perform, in a simple, easy, non-contaminating and non-destructive manner, a verification or measurement of the filtration power of filter elements.

The invention in particular aims to make it possible to verify the integrity of a filter element at the end of its manufacturing and verification cycle, and to thus reliably guarantee a filtration power by the fact that no subsequent mechanical or hydraulic operation will later modify the characteristics of the filter element.

These aims are attained thanks to a process for verification of a filter element by infrared radiation, characterized by the fact that it includes the following steps:

a) a fluid at a predetermined temperature is circulated through the filter element which is to be verified, the predetermined temperature being appreciably different from that of the filter element,

b) the infrared radiation passing through the filter element which is to be verified is observed and detected,

c) an image process from the detected infrared radiation is performed in order to observe and locate possible unevennesses of flow rate revealing defects on the surface of the filter /3
element.

According to the invention, the filter element is simply run through by a non-contaminating fluid such as a liquid, or preferably a gas, such as nitrogen or a neutral gas, whose essential characteristic lies in the temperature, which is appreciably different from that of the filter element. Therefore, a wide range of appropriate non-contaminating fluids exists, seeing that the only important factor consists of a difference in temperature.

Furthermore, the observation using an infrared detection device occurs in a purely passive manner, and it is not necessary to apply any radiation to the filter element.

According to a particular embodiment, the observation takes place by gradually increasing the pressure of the gas or the flow rate of the liquid which is applied to the filter element.

In case of filtration defect, a fluid flow rate greater than or less than what it is on the average over the whole surface of the filter is locally observed. By increasing the pressure or the flow rate, the whole outside of the filter appears as allowing the gas or the liquid to pass through.

By analogy with the "bubble point" method and after standardization, the value of pressure or of flow rate for which the first defect appears constitutes a threshold which indicates the filtering power of the element which is measured.

According to an advantageous embodiment which is easy to implement, the filter element is maintained at a temperature in the vicinity of room temperature, and the fluid consists of a hot fluid brought to a temperature greater than or equal to approximately 50°C.

However, according to another embodiment, the filter element is maintained at a temperature appreciably lower than approximately -50°C, and the fluid consists of a cryotechnical fluid brought to a temperature appreciably greater than -50°C and less than 0°C. In /4
this case, the infrared detection device must naturally be suitable for detection in this range of temperatures.

In a general manner, the processing of the data can take place in different ways.

According to a first embodiment, during the image processing, the zones of the surface of the element in which a temperature greater than a predetermined temperature has been detected are highlighted.

According to another embodiment, during the image processing, the map of the temperatures observed according to a predetermined temperature scale is expressed by an index relating to the quality of the filter element.

The invention can be applied in particular to filter elements consisting of filters intended for fine filtration which are capable of retaining particles between a few micrometers and around one hundred micrometers.

The invention also relates to a device for verification of a filter element by infrared radiation, characterized by the fact that it includes:

a) a support for a filter element which is to be verified, which is maintained at a roughly constant temperature,

b) a source of fluid whose pressure or flow rate can be adjusted,

c) some means for bringing the fluid to a predetermined temperature which is appreciably different from that of the filter element and of its support,

d) some means for circulating the fluid at said predetermined temperature, through the filter element,

e) an infrared detection device arranged facing the filter element which is to be verified in order to detect the unevennesses of flow rate of the fluid passing through the filter element, and

f) some image processing means for determining, from the detected infrared radiation, the quality of the filter element which is to be verified.

The filter element support can include a sealed cell which is not thermally insulated, /5
placed in a thermostat.

The fluid source can be a source of gas, provided with means for adjustment of the pressure or a source of liquid provided with some means for adjustment of the flow rate.

Advantageously, the device includes, upstream from the filter element, an additional filter whose filtering power is much lower than the filtering power of the filter element which is to be verified.

According to a particular embodiment, the infrared detection device consists of a small bar of CCD elements having a relative movement with respect to the filter element in order to sweep the whole surface of this element.

According to another particular embodiment, the infrared detection device consists of an infrared video camera.

In a general manner,

· a flat filter can be observed in all of its surface.

· a flat or cylindrical filter can be observed according to a rectangular surface of small width which sweeps the surface of this filter.

· a flat, cylindrical or any shaped filter can be observed according to a spot which sweeps the surface of this filter.

In all cases, the direction of the observation is approximately perpendicular to the surface of the filter in the observation zone.

The infrared detection device can include an infrared video camera, and a screen provided with an observation slit inserted between the infrared video camera and the filter element, some means being provided for bringing about a relative movement between the filter element and the slit so that the slit constitutes a window of observation sweeping the whole surface of the filter element.

In the case of a cylindrical filter, the filter can, for example, be rotated around its axis in front of the observation window which remains stationary.

Brief description of the drawings /6

Other characteristics and advantages of the invention will emerge from the description of particular embodiments given as examples in reference to the appended drawings in which:

- Figure 1 is a diagrammatic view of a whole device for verification of a filter according to a first embodiment of the invention,

- Figure 2 is a diagrammatic view of a whole device for verification of a filter according to a second embodiment of the invention,

- Figure 3 is a front view showing a detail of a particular embodiment with observation slit,

- Figure 4 is a view in section according to line IV-IV of Figure 3,

- Figure 5 is an execution variant of Figures 3 and 4, showing an infrared detection device consisting of a small bar of CCD elements (charge coupling elements) [CCD = charge coupled device],

- Figure 6 shows a simplified image of a filter with a defect obtained by the process according to the invention, and

- Figure 7 shows curves giving, as a function of time, the change in temperature at different points of the filter whose image is represented in Figure 6.

Detailed description of particular embodiments

Figure 1 diagrammatically shows a whole installation for verification of a filter according to the invention.

Filter element 7 which is to be verified is arranged facing infrared detection device 5 which advantageously consists of an infrared video camera, which is itself associated with image analysis system 6 making it possible to quantify the result of the measuring.

Pipe 8 is arranged in such a way that it is possible circulate a fluid, which is a neutral gas /7
in the example in consideration, through filter element 7.

The circuit for application of the neutral gas to filter 7 includes adjustable pressure reducing valve 1 making it possible to vary the pressure of the gas in a predetermined range of values which can range, for example, from 0 to a few ten thousand pascals.

Filter 2, whose filtering power is much less than the filtering power of element 7 which is to be measured, is arranged on the circuit for application of the neutral gas, for example, downstream from pressure reducing valve 1.

The pressure reduced gas is brought to a predetermined temperature in heat exchanger 3 situated downstream from filter 2.

Pressure gauge 4 makes it possible to measure the pressure of the gas at the entrance of element to be measured 7.

In the case in which filter element 7 is maintained at a temperature in the vicinity of room temperature, for example, at a temperature on the order of 20°C, the pressure reduced fluid applied by pipeline 8 can advantageously be heated in heat exchanger 3 to a temperature greater than approximately 50°C, for example, on the order of 80 to 100°C, so that it is introduced into filter 7 with a substantial temperature difference, so that infrared camera 5 can detect leakage of hot fluid through the wall of filter 5 as the pressure of the gas increases from a pressure of zero.

Figure 1 shows the use of a gaseous fluid. A non-contaminating liquid can be used as fluid allowing infrared detection if the temperature gradient is sufficient.

The device according to the invention is more particularly suitable for verifications of filters for the purpose of a manufacturing process, before use of these filters.

However, in the case in which the filter does not have a casing which is opaque to infrared radiation or if this casing can be removed, the device according to the invention can also
be suitable for verifications in situ. /8

In this case, as an example, the verification can take place using cleansing gas (heated nitrogen) in the case of propulsive assemblies or using a lubricant in the case of a thermal engine.

Figure 2 shows an assembly which is rather similar to that of Figure 1, which can be applied in particular to the verification of flat samples of porous material 7.

In the case of Figure 2, sample 7 which is to be verified is held between two frontal plates 71, 72 which only leave room necessary for the application of a fluid from pipeline 8 which is perpendicular to the plane of sample 7, and for the evacuation of this fluid 73 through the side of sample 7 turned towards infrared observation camera 5. The measuring cell has lateral wall 74 which provides sealing with regard to the exterior without constituting a thermal barrier.

The measuring cell is placed in tank 10 filled with liquid maintained at a constant temperature in order to constitute a thermostat, pipelines 11, 12 providing circulation of the liquid inside of tank 10.

The fluid applied in pipeline 8 passes through automatic flow rate control device 9 and then through furnace 3 in which it is heated to a temperature appreciably higher than that of the liquid contained in tank 10, which overcomes the temperature of sample 7. Furnace 3 can have a central pipeline connected by flanges 31, 32 to pipeline elements 8.

The hot fluid used to run through sample 7 can be nitrogen, for example.

Temperature measuring devices such as thermocouples are placed on the surface of the sample and in the stream of the gaseous fluid. However, in order to perform a fine and precise analysis of the behavior of the material of sample 7, infrared camera 5 provides the display of the thermal gradients on the surface of sample 7, and thanks to the associated image processing /9
device, makes it possible to measure the distribution of the temperatures as a function of the passage of the hot fluid through the surface of the sample, which contributes towards characterizing the porosity properties.

The measuring device according to the invention is particularly suitable for appraisal and verification in the manufacturing of filters of metallic cloth, sintered element (for example, sintered nickel), composite element or ceramic element types; the filters can have mesh sizes such that they are capable of retaining particles of a few microns to approximately one hundred microns.

The infrared detection device can advantageously consist of a camera provided with a zoom, which makes possible precise examinations in the plane of the filter. Thus, the invention is quite suitable for the examination of porosities, and suction of gas intended for obtaining a uni-directional flow is not necessary.

The resolution of the process is only limited by that of the infrared detector.

In a certain number of cases, the infrared detector can consist of a simple bar of charge coupled devices (CCD). For example, represented in Figure 5 is bar 5' of CCD elements which are placed parallel to the axis of cylindrical filter 7 which is run through by a fluid with a temperature gradient with respect to filter 7. By rotation of filter 7 around its axis, detector 5' can sweep the whole surface of filter 7 which passes successively in front of detector 5'.

In the case of use of infrared camera 5, it is also possible to reduce the observation to a limited zone of cylindrical filter 7, for example, by inserting plate 50 between camera 5 and filter 7, plate 50 being provided with slit 51 parallel to a generating line of cylinder 7 so that the observation is limited to the portion of the surface of the filter which is roughly normal to plate 50, that is to say in the axis of camera 5. By rotation of cylindrical filter 7, the whole surface of /10
this filter can be successively swept (Figures 3 and 4).

Described in the preceding is the case of use of a fluid brought to a temperature clearly higher than room temperature, constituting the simplest embodiment to implement.

Inasmuch as certain infrared cameras are themselves capable of tolerating temperatures lower than 0°C, it is also possible to cool the installation which supports filter 7, for example, tank 10 of Figure 2, to very low temperatures, for example, to the temperature of liquid nitrogen or to temperatures on the order of -90°C, and to apply a fluid consisting of a cryotechnical gas which can be, for example, at a temperature on the order of -50°C.

In certain cases, instead of detecting the fluid passing through filter 7, it is possible to maintain filter 7, for example, at room temperature, to circulate a cryotechnical fluid, for example, at approximately -50°C through filter 7, and to observe the zones with higher temperature constituted by filter 7 itself.

The information delivered by infrared detection device 5 can be processed in such a way as to provide measurements which, after standardization, can be correlated with those obtained by conventional methods for verification of filters (bubble point, glass balls).

Measurements can be deduced from the observations made by an infrared detection device, for example, by:

- exceeding of a pre-defined temperature threshold at a pre-defined number of points of the surface of the filter,
- calculation of an index allowing the map of temperatures to be expressed.

It should be noted that the device according to the invention makes it possible to do qualitative observations and quantitative measurements taking into account a single basic factor, /11 namely the temperature. In effect, when the pressure of the fluid increases, the flow rate of fluid is higher, and this is expressed simply by a more rapid rise in temperature.

The process and the device according to the invention make it possible to observe a change in transitory terms, for example, when the temperature at the site of the filter increases because of an increase of the pressure of the fluid starting from an initial instant of the beginning of verification, and also to perform verifications in stabilized flow under reproducible conditions.

Inasmuch as the emissivity of the material in consideration is itself known, it is possible to obtain a map of temperatures directly with the image processing system associated with the camera.

The presence of a defect is characterized by a spot corresponding to a high temperature. The larger the defect is, the larger the spot obtained is and corresponds to a product of high temperature.

From a standardization, the minimum tolerable defect is assessed. The different filters which are verified can receive a quality index as a function of the defects observed.

Represented in Figure 6 is an example of an infrared mapping obtained using infrared camera 5 placed in front of filter 7 which is run through by a hot fluid according to the process according to the invention, and which allows information as to the quality of the observed filters to be deduced from it.

It is recalled that thermal imaging is a method which makes possible the acquisition of phenomena connected with the spatial distribution of heat on examined bodies. It also allows the observation of variations of this distribution in time.

The system transforms an infrared image into a visible image. The infrared image of the object, explored by sweeping of a surface, gives a video signal on the detector, whose amplitude varies in time as a function of the variations of luminance encountered.

Figure 6 shows a thermogram corresponding to the digital processing of the thermal /12
image coming from the camera. In the example which is illustrated, the distribution of the map of temperatures which must be considered in terms of relative value has been simplified so as to cause only four different temperature ranges to appear. In reality, with a color thermogram, it is possible to present a much higher number of temperature ranges, for example, at least 16 different temperature levels.

Figure 6 shows a filter with defect 101 on the front side, and five points 111 to 115 distributed over the surface of the filter for which the course of temperature is monitored. It is observed in Figure 7, which shows the course of temperature at points 111 to 115 (curves 121 to 125 respectively), that at point 114 where the defect is, there is a temperature change (curve 124) which is much more rapid than for the other points.

In the case of Figure 6, the defect being situated on the front side of the filter, this defect is expressed by a greater passage of hot fluid and therefore an increase of temperature. A defect situated on the back side causes the appearance of a different temperature distribution. A part of the thermal energy is evacuated through the defect, which causes the front side to appear as being colder.

Claims /13

1. A process for verification of a filter element by infrared radiation, characterized by the fact that it includes the following steps:

a) a fluid at a predetermined temperature is circulated through filter element (7) which is to be verified, the predetermined temperature being appreciably different from that of filter element (7),

b) the infrared radiation passing through filter element (7) which is to be verified is observed and detected,

c) an image processing from the detected infrared radiation is performed in order to observe and locate possible unevennesses of flow rate revealing defects on the surface of filter element (7).

2. A process according to Claim 1, characterized by the fact that said fluid is a non-contaminating gas, such as nitrogen or a neutral gas.

3. A process according to Claim 1, characterized by the fact that said fluid is a non-contaminating liquid.

4. A process according to Claim 2, characterized by the fact that the observation takes place by gradually increasing the pressure of the gas.

5.A process according to Claim 3, characterized by the fact that the observation takes place by gradually increasing the flow rate of the liquid.

6.A process according to any one of Claims 1 to 5, characterized by the fact that filter element (7) is maintained at a temperature in the vicinity of room temperature, and the fluid consists of a hot fluid brought to a temperature greater than or equal to approximately 50°C.

7. A process according to any one of Claims 1 to 5, characterized by the fact that filter element (7) is maintained at a temperature appreciably lower than approximately -50°C, and the fluid consists of a cryotechnical fluid brought to a temperature appreciably greater than -50°C and less than 0°C.

8. A process according to any one of Claims 1 to 7, characterized by the fact that during /14
the image processing, the zones of the surface of the element in which a temperature greater than a predetermined temperature has been detected are highlighted.

9. A process according to any one of Claims 1 to 7, characterized by the fact that during the image processing, the map of temperatures observed according to a predetermined temperature scale is expressed by an index relating to the quality of filter element (7).

10. A process according to any one of Claims 1 to 9, characterized by the fact that filter element (7) consists of a filter intended for fine filtration which is capable of retaining particles between a few micrometers and around one hundred micrometers.

11.A process according to any one of Claims 1 to 10, characterized by the fact that filter element (7) consists of a metallic cloth, a sintered element, a composite element or a ceramic element.

12. A process according to any one of Claims 1 to 10, characterized by the fact that filter element (7) consists of a porous material.

13. A device for verification of filter element (7) by infrared radiation, characterized by the fact that it includes:

a) support (10) for filter element (7) which is to be verified, which is maintained at a roughly constant temperature,

b) source of fluid (1; 9) whose pressure or flow rate can be adjusted,

c) some means (3) for bringing the fluid (1; 9) to a predetermined temperature which is appreciably different from that of filter element (7) and of its support (10),

d) some means (8) for circulating fluid (1; 9) at said predetermined temperature, through filter element (7),

e) infrared detection device (5) arranged facing filter element (7) which is to be verified in order to detect the unevennesses of flow rate of fluid (73) passing through filter element (7), and

f) some image processing means (6) for determining, from the detected infrared radiation, the quality of filter element (7) which is to be verified.

14. A device according to Claim 13, characterized by the fact that support (10) of filter element (7) includes sealed cell (71, 72, 74) which is not thermally insulated, placed in thermostat (10).

15.A device according to Claim 13 or 14, characterized by the fact that fluid source (1; 9) is a source of gas and has some means for adjustment of the pressure.

16. A device according to Claim 13 or 14, characterized by the fact that fluid source (1; 9) is a source of liquid and has some means for adjustment of the flow rate.

17. A device according to any one of Claims 13 to 16, characterized by the fact that it includes, upstream from filter element (7), additional filter (2) whose filtering power is much lower than the filtering power of filter element (7) which is to be verified.

18. A device according to any one of Claims 13 to 17, characterized by the fact that infrared detection device (5') consists of a small bar of CCD elements having relative movement with respect to filter element (7) in order to sweep the whole surface of this element.

19.A device according to any one of Claims 13 to 17, characterized by the fact that infrared detection device (5) consists of an infrared video camera.

20. A device according to any one of Claims 13 to 17, characterized by the fact that the infrared detection device includes infrared video camera (5) and screen (50) provided with observation slit (51) inserted between infrared video camera (5) and filter element (7), and by the fact that some means are provided for bringing about relative movement between filter element (7) and slit (51) so that slit (51) constitutes a window of observation sweeping the whole surface of filter element (7).

//scan Figures 1-7//

FRENCH REPUBLIC
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Application Number
FR 9016514
FA 455126

SEARCH REPORT
established on the basis of the most recent claims filed before the start of the search

DOCUMENTS CONSIDERED TO BE RELEVANT		Claims concerned in the examined document	
Category	Citation of document with indication where appropriate, of relevant passages		
Y	GB-A-2164746 (GENERAL ELECTRIC COMPANY USA) * the whole document *	1, 2, 6, 13, 15, 19	
A	* idem * ---	4, 7-9	
Y	NTIS DATABASE National Technical Information Service, US Department of Commerce, Springfield, VA, US A. P. PONTELLO: "A test method for nondestructive testing of fuel filtration equipment"; Accession No. AD-743 081 * the whole document * ---	1, 2, 6, 13, 15, 19	
A	HIGH TEMPERATURE Vol. 12, No. 5, May 1975, NEW YORK US pages 949-953; N.S. LIDORENKO ET AL: "New method for investigating the permeability of porous materials" * the whole document * -----	1, 3-6 10-14, 16, 20	TECHNICAL FIELDS SEARCHED (Int. Cl.5) G01N

Date of completion of the search	Examiner
SEPTEMBER 11, 1991	JOHNSON, K

CATEGORY OF CITED DOCUMENTS

X: Particularly relevant if taken alone.
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D: Document cited in the application.
L: Document cited for other reasons.

&: Member of the same patent family, corresponding document.

FIG. 1

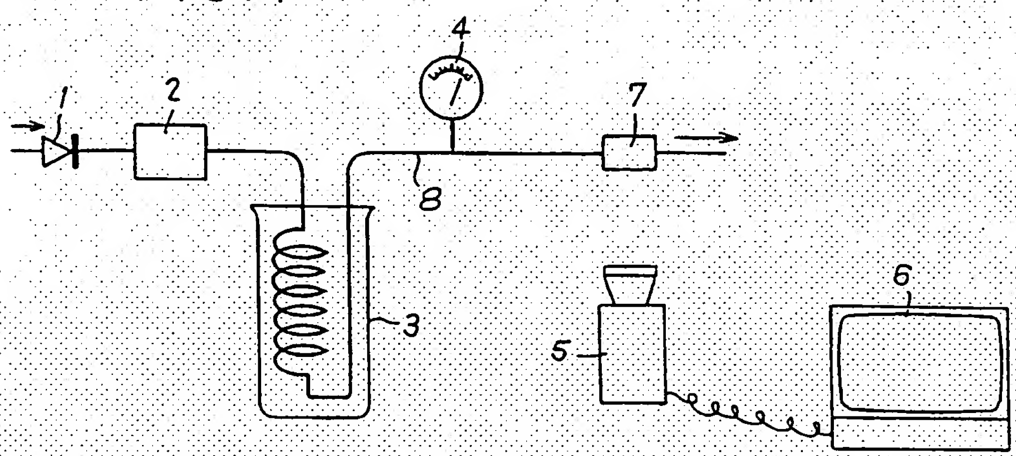

FIG. 2

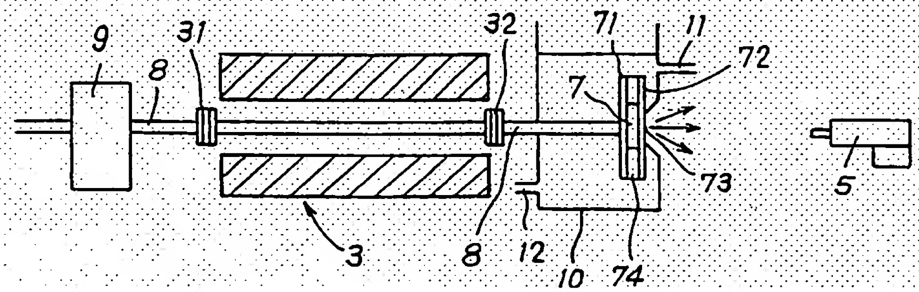

FIG.3

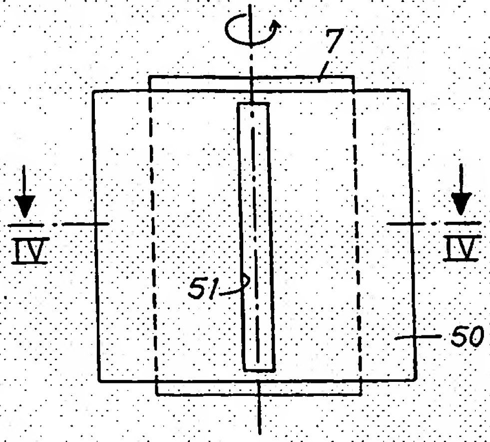

FIG.4

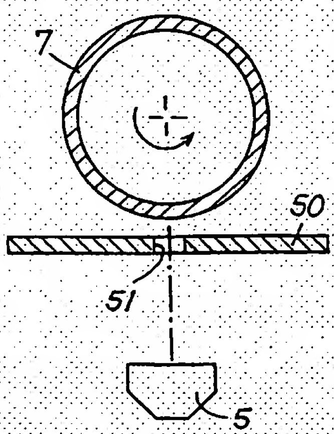

FIG.5

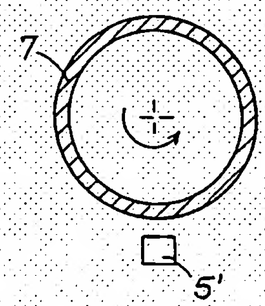

FIG.6

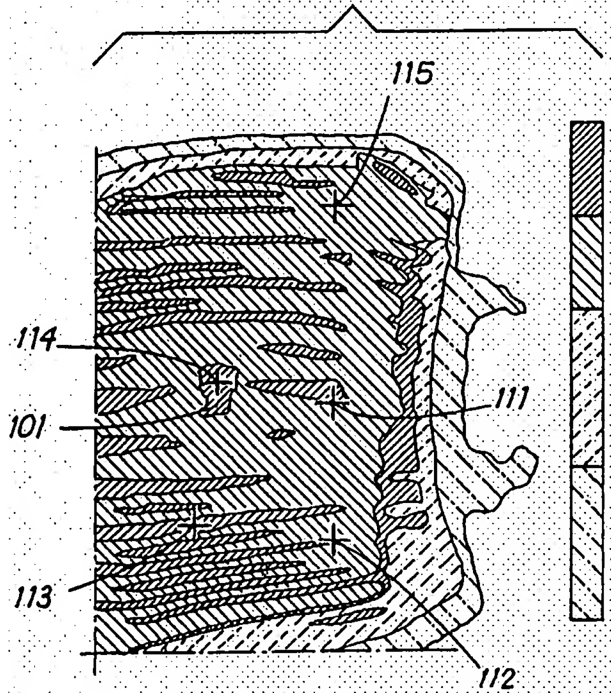
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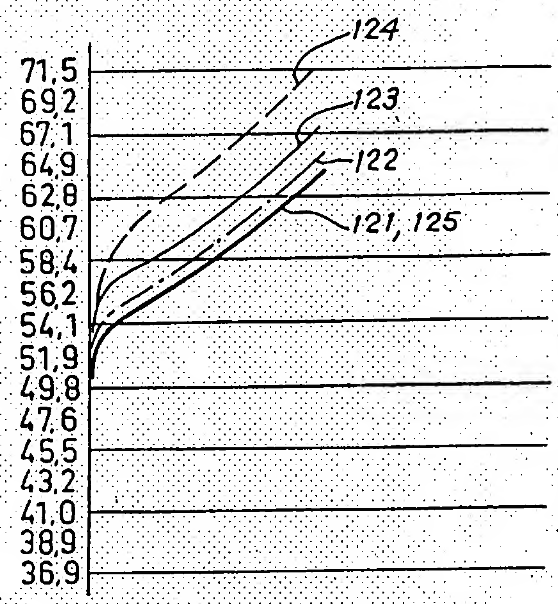
FIG.7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